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SERVICE MANUAL
742
UNIT

Converter test kit OPTIMUS
for OPTIMUS 50/65/80 generators Release 3.x
with converters 4512 104 7231 1/2/3

4512 104 91681

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SERVICE MANUAL - UNIT

Converter test kit OPTIMUS
for OPTIMUS 50/65/80 generators Release 3.x
with converters 4512 104 7231 1/2/3

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Type No: 4512 104 91681

In case there are any questions concerning this manual,
please send this LOPAD via fax to 49/(0)40/5078 2481

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0.5 A4 (Orange cardboard)
1
3

5 ... 42 (02.0)

6-01 (b/01.0) OPTIMUS RAD
6-1 ... 6-14 (b/01.0) OPTIMUS RAD

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1. Introduction

With this document it should be possible to determine which part of kV units of an Optimus generator is still operational and which part is defective and has to be replaced.

1.1. Scope of delivery

- 2 current transformers
  (ratio 1:1000, 20Ω resistors at the secondary coil give a ratio of 50A primary / 1V secondary)
- Test cable with resistor
- Test cable with diode
- Unit Manual Converter R/F
- This documentation

1.2. Tools

- Standard tools
- Extension boards C (96-pin)
- Dual trace oscilloscope with:
  - 2 probes for signals
  - 1 probe for external triggering
- Multimeter with diode test option
- 1 battery 1.5V D cell (R20) preferred
  C cell (R14) or AA cell (R6) possible

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2. Generator condition after failure event

ENF1 and/or **ENF2** and/or **ENF3** tripped.

Mains fuses might have additionally tripped.

2.1. Special case

ENF3 tripped, possibly in combination with ENF2 and? ENF1 and? mains fuses:

Problem most likely caused by rotor control unit EY (high speed) or EYA (low speed).
Solutions for rotor control problems are not part of this document.

2.2. All other cases

The generator has to be kept in this condition to discover the cause of the problem.

A non-qualified person (e.g. hospital technician not familiar with Optimus) should not be asked to just turn the fuses back on to prevent further damage.

A qualified person like a Philips field engineer (trained on Optimus) must visit the site.

2.3. Prerequisites before checking the generator

CAUTION!

Do not remove PCB kV-power from the IGBT transistors.
Electrostatic discharge and mobile phone waves can damage and destroy IGBTs when gate connections are open.

WARNING!

The generator must be switched OFF and must be completely cut from mains (e.g. room mains switch or earth leakage current breaker).

All following checks must be made without mains power.

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3. Check of generator mains supply parts

- Measure DC voltage at auxiliary contacts 41-42 of ENK2.
  (Converter DC discharging contact, max voltage can be 750VDC.)

  If 0V is measured:

  - the contact is closed (and the converter DC is discharged within 1 minute)

  or

  - the contact is open and the converter DC is discharged and safe.

WARNING!

In case one of the ENK2 main contacts is welded the converter DC discharge time is much longer as the discharging auxiliary contact ENK2 41-42 cannot be closed.

600VDC discharge time to < 60VDC normally 40 seconds.
With open contact > 11 minutes to be < 60VDC.

- Check if any main contact of contactor ENK2 is welded:

  Mechanical check: If snap-on auxiliary contacts or auxiliary contact block cannot be removed from the main contactor at least one contact is welded.

ENK2	phase 1	1 - 2	contactor ENK2	2422 132 06621
	phase 2	3 - 4	+ 3 aux. contacts NO	2422 135 04355
	phase 3	5 - 6	+ 1 aux. contact NC	2422 135 04023
			or	
			successor contactor	2422 132 07381
			+ succ. aux. cont. block	2422 135 04464
			+ succ. R/C circuit	2422 135 04661

- Record the conditions on last page.

- If contacts have been found to be welded replace contactor, its auxiliary contacts or contact block + the R/C circuit.

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3.1. Condition(s) when the service comes to the site

3.1.1. ENF2 tripped, possibly in combination with ENF1 and? mains fuses

Problem might be caused by any of the:

- internal generator units (Optimus RAD + R/F)

or

- external units (Optimus RAD only) connected to breaker ENF2 :T1 :T2 :T3.

Solutions for such a case are not part of this document.

3.1.2. ENF1 tripped, possibly in combination with mains fuses

Problem most likely caused by kV unit malfunction (kV-control, kV-power, converter(s), HV transformer) or external parts e.g. HV cable(s) or tube.

WARNING!

Make sure that the DC voltage in the converter is discharged.

- Open the cover of the frontal (and rear where present) converter.
- Measure DC at PCB kV-power EQ100 at E2 – C1 (at both converters, see layout drawings attached). The measured DC must be < 10VDC.

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3.2. Check for open springs at damping resistors

EN :R1 safety resistor 47Ω 100W 4512 100 45441
:R2
:R3

- Record the conditions on sheet of appendix.

- Check for open springs at damping resistors.
  Springs might be open if all breakers are ON when the service comes to the site.
  In this case the generator must have been switched ON after all fuses and breakers were reactivated.
  Short-circuit in the converter or its mains rectifier/filter could have happened.
  Springs can be resoldered. If the springs have to be resoldered, use as little solder as possible.

- Check that the ceramic resistor bodies do not have cracks. In case of cracks the springs must be resoldered.

3.3. Check for contacts that are welded at breakers and contactors

- Switch OFF breakers ENF1 and ENF2.

ENF1	L1 – T1 L2 – T2 L3 – T3		automatic circuit-breaker ENF1	Optimus 50		2422 129 15514
					or successor	2422 129 16291
				Optimus 65/80		2422 129 15513
					or successor	2422 129 16292
ENF2	L1 – T1 L2 – T2 L3 – T3		automatic circuit-breaker ENF2	Optimus 50/65/80		2412 129 00341
					or successor	2422 129 16288
ENK1	phase 1 phase 2 phase 3	2 – 1 4 – 3 6 – 5	contactor ENK1	Optimus 50		2422 132 06625
					or successor	2422 132 07382
					+ R/C circuit	2422 135 04662
				Optimus 65/80		2422 132 06624
					or successor	2422 132 07383
					+ R/C circuit	2422 135 04662

- Record the conditions of the breakers in the appendix.

- Check for contacts that are welded at breakers and contactors.
  If contacts have been found to be welded replace breaker(s) and/or contactor(s).

- Remove the converter mains lines (frontal and rear converter) from contactor ENK1 :1 :3 :5.
  Measure with an ohmmeter each line against the others (of each converter).
  There should be no short-circuit, the meter should display 2MΩ ±5% after at least 20 seconds (filter resistors).

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4. Converter checks (EQ frontal and E2Q rear)

4.1. Visual converter check

- Check the converter visually.
  The entire converter chassis must be replaced if cracks are visible at the white IGBT body (looking through the converter cage grid) or if the kV-power PCB Q100 is bent towards the cover plate.

4.2. Measuring of converter parts

Use an ohmmeter which has a diode test feature.

- Check the polarity of the meter (for ohm and diode testing):

  Anode of diode symbol on meter = positive voltage >> **PLUS** (see measurement)

  Cathode of diode symbol on meter = negative voltage >> **MINUS** (tables)

Ω = Normal ohm measurements
➔ = Diode test option of meter

4.2.1. Rectifier check

- Open the right side of the converter(s) to get access to the mains rectifier.

L1 ⊘	⊘	–
L2 ⊘	⊘	–
L3 ⊘	⊘	+

Rectifier EQV5 layout

MINUS	PLUS ➔		PLUS	MINUS ➔	
L1 / L2 / L3 ⊘	⊘ –	⊘ +	L1 / L2 / L3 ⊘	⊘ –	⊘ +
	450mV ±10%	∞		∞	450mV ±10%

- Record the conditions in the appendix.

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4.2.2. IGBT check

Legend

typical values when part is OK
typical values of defective parts If at least one test fails the converter must be exchanged. Proceed with chapter 5.

The table below shows results of IGBT emitter - collector measurement.
Converter working OK and completely assembled.
Q100 kV-power PCB 4512 108 0862x / 0934x

MINUS	PLUS	Ω	→	PLUS	MINUS	Ω	→
E1 E2,3,4	C1 C2,3,4	21.5 - 22kΩ	∞	E1 E2,3,4	C1 C2,3,4	16.5kΩ ±10%	300mV ±10%
Ex	Cx	0 Ω	< 200mV	Ex	Cx	0Ω	< 200mV

The table below shows values of IGBT gate - emitter resistances.
Converter working OK and completely assembled.
Q100 kV-power PCB 4512 108 0862x / 0934x

MINUS	PLUS	Ω	PLUS	MINUS	Ω
G1 G2,3,4	E1 E2,3,4	3.8kΩ ±10%	G1 G2,3,4	E1 E2,3,4	4.2kΩ ±10%
Gx	Ex	0Ω	Gx	Ex	0Ω

- Record the conditions in the appendix.

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4.2.3. Overvoltage diode check

cathode = heat sink plate

MINUS	PLUS	➔	PLUS	MINUS	➔
cathode V500 V501,2,3	anode V500 V501,2,3	310mV ±10%	cathode V500 V501,2,3	anode V500 V501,2,3	∞
cathode V5xx	anode V5xx	0	cathode V5xx	anode V5xx	0

- Record the conditions in the appendix.

4.2.4. Resistor check (PCB versions 4512 108 0862x / 0934x)

- Check 2 groups of 3 parallel resistors:

  R506 / 507 / 508
  and
  R509 / 510 / 511

  With 39Ω ±5% per group. Each resistor must have a resistance of 13Ω ±5%.

- Record the conditions in the appendix.

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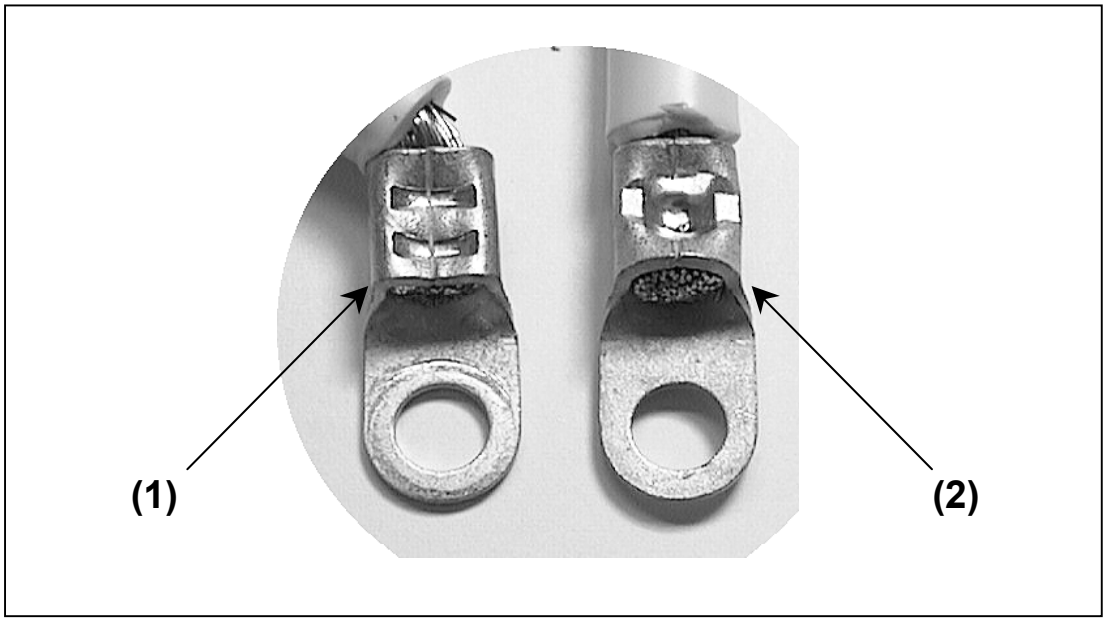
4.2.5. Power cable harness check

- Check internal converter power cable connections at resonance capacitors C3:2 and C13:2.
  If the connectors look like (2) no additional action is necessary.
  If one of the connectors looks like (1) and if signs of overheating are visible replace the converter.



- Record the conditions in the appendix.

4.2.6. Resonance capacitor check

- Remove primary lines from resonance capacitors C3:1 and C13:1 of frontal (and rear) converter.
- Check both capacitors for:
  - short-circuit
  - open connection

As it is not possible to measure the capacitance with an ohmmeter it is sufficient to see a variable resistance value for a certain time and finally a high resistance or open connection.
Once a high resistance or open connection is displayed reverse the measuring lines. If it comes again to an unstable resistance display with a high resistance or open connection display at the end, the capacitor should be OK.

If a capacitance measuring device is available it should display 8µF ±5% (apart from the meter tolerance).

If a capacitor is defective (short or open) and no other part of the converter is defective which requires a converter unit exchange, replace the capacitor (2019 321 00016).

- Record the conditions in the appendix.

NOTE
Leave the primary lines disconnected from the capacitors for further tests.

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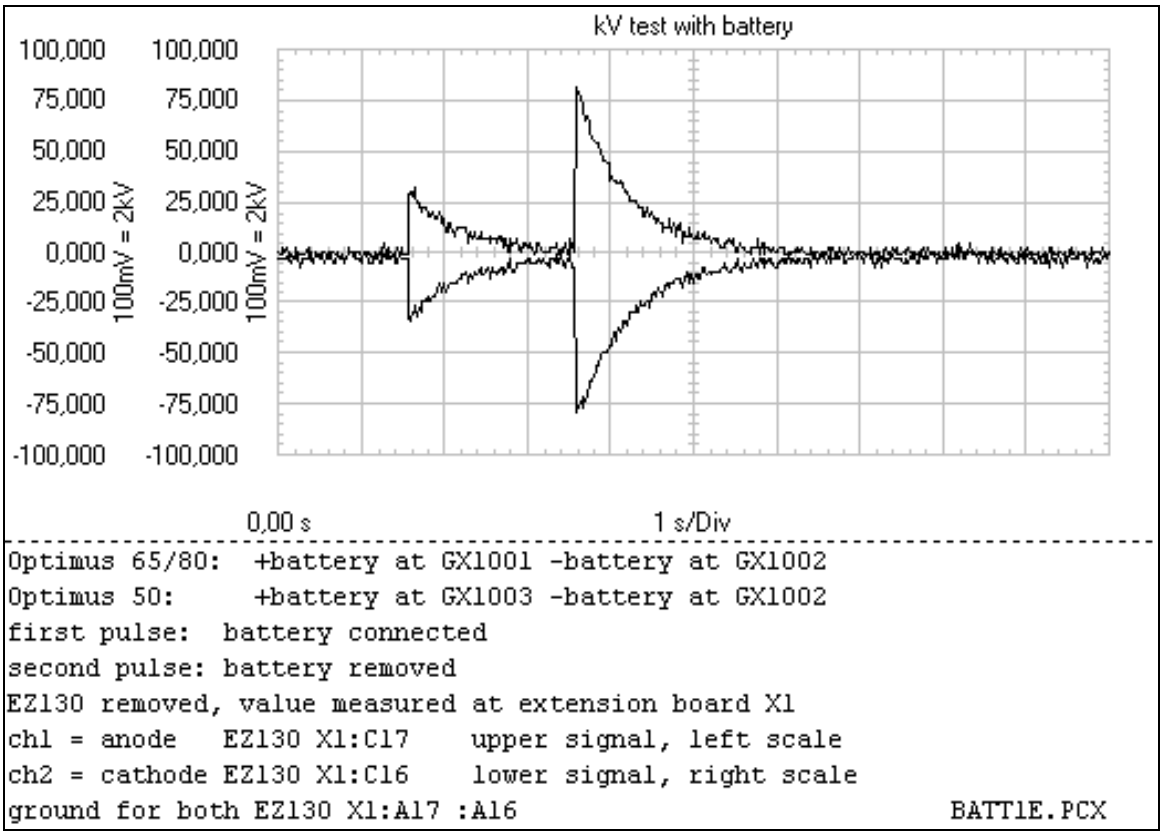
5. Check of the high voltage transformer

- Remove PCB EZ130 kV-control.
- Insert extender PCB at EZ130 X1 (or use the backpanel connections, which is less convenient).
- Establish oscilloscope connections:

channel 1	=	anode	EZ130 X1:C17	10 or 20mV/div
channel 2	=	cathode	EZ130 X1:C16	10 or 20mV/div
ground	=		EZ130 X1 :A17 :A16	
trigger	=	positive slope anode ch1 or negative slope cathode ch2 trigger level according to signal level		
time base	=	500ms/div or 1s/div		

Signal amplitudes might look different depending on the battery type, connection cables used and the "contact force" at the battery.



- Measure
  - **(1)** with high voltage cables and tube connected.
  - **(2)** with high voltage cables only.
  - **(3)** without high voltage cables connected.

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5.1. Analysis

(1) and **(2)** have to look almost the same (symmetry and amplitude).

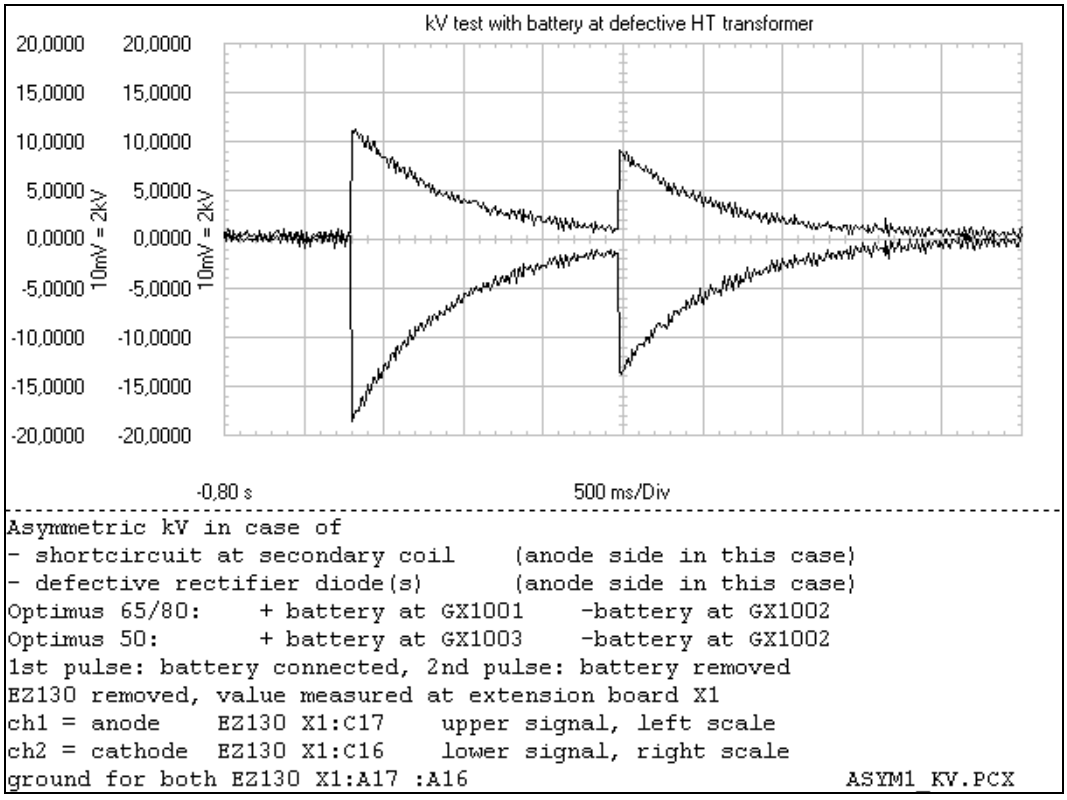
If **(1)** has a lower amplitude or a different kV behavior compared to **(2)** and **(3)** the tube might be defective.

(3) should have a steeper (faster) discharging ramp as the capacitance of the HV cable is missing (tank only 3nF, 20m cable typically 1.5nF) assuming amplitude and symmetry are the same.

If **(2)** and **(3)** look different (amplitude and symmetry) and if **(3)** is symmetric the HV cable(s) might be defective.

If **(3)** shows an asymmetric amplitude the HV tank must be replaced.

- Check against the following chart:


kV test with battery at defective HT transformer
20,0000
15,0000
10,0000
5,0000
0,0000
-5,0000
-10,0000
-15,0000
-20,0000
10mV = 2kV
-0,80 s
500 ms/Div
Asymmetric kV in case of
- shortcircuit at secondary coil (anode side in this case)
- defective rectifier diode(s) (anode side in this case)
Optimus 65/80: + battery at GX1001 -battery at GX1002
Optimus 50: + battery at GX1003 -battery at GX1002
1st pulse: battery connected, 2nd pulse: battery removed
EZ130 removed, value measured at extension board X1
ch1 = anode EZ130 X1:C17 upper signal, left scale
ch2 = cathode EZ130 X1:C16 lower signal, right scale
ground for both EZ130 X1:A17 :A16
ASYM1_KV.PCX

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6. Visual check of the X-ray tube

- If possible remove the collimator and the X-ray tube window assembly.
  is there any visible damage?

  A cracked tube or the loss of its vacuum could be a reason to destroy the converter.

- Record the conditions in the appendix.

7. Interim results

At this point
- generator parts and units
- tube(s)
- HV cables

have been checked.

Something might have been exchanged or all tests came to an OK-result.

- Remove the extender PCB and reinsert kV-control EZ130.

WARNING!

All followings checks must be made with mains power.

Check that the converter mains lines still have no connection to mains at ENK1 :1 :3 :5

- Switch ON all generator breakers and the mains supply.

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8. Tube check with Rotor Control part 1

In case the tube was rotating during tripping of mains breakers the CPU remembers that the brake process has not been carried out (high speed rotor control only).
About 40 seconds after switch-ON the tube brakes.

> **NOTE!**
> *If the anode disk is not rotating before switch-ON it sounds like an acceleration process.*

- Switch ON the generator and perform an audible check at the tube housing during the generator start-up (for further explanations see chapter 10.)

As the mains lines are not connected to the converters, error messages 02HI and 02HJ come up (converter DC is 0V, therefore out of range).

9. kV-driver test

- Perform the kV-driver test according to chapter 5.3 of the Converter R/F manual attached.

If the kV-driver test is successful prepare the generator for a next test:

WARNING!
Switch the generator OFF.
Cut the generator completely from mains.

- Lead the primary power cable(s) of QC13:1 (front and rear) through the current transformer(s) at each converter and reestablish the connection to the capacitor.

  Optimus 65/80 with 2 converters:
  Both current transformers must be inserted the same way.
  (Polarity, secondary transformer pins are marked with 1 and 2).

- Reestablish primary cable(s) at QC3:1 too.

- Reestablish all connections (mains cables of converter(s) at ENK1 :1 :3 :5.

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10. Tube check with Rotor Control part 2

- Switch ON the generator.
  The system and the generator should be in ready condition.

Check of the tube vacuum:

- Push and hold PREP.
- Switch OFF the generator.
  The anode is in free run now.
- Listen at the tube housing:
  - If the anode speed is down within 2 ... 3 minutes the tube is defective (no vacuum) and must be replaced.
  - If a decrease of anode speed is not audible within several minutes the vacuum is still OK.

- Switch the generator back ON.
  - A generator with high-speed rotor control brakes the tube automatically (chapter 8).
  - At generators with low -speed rotor control wait for ready condition, push PREP once and let go of the PREP switch to brake the tube.

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11. Tube and high-voltage cable test with high voltage

Even if

- the battery test to check a short at the high voltage cables (chapter 5),
- the visual tube check (chapter 6) and
- the audible tube check (chapters 8 + 10)

did not lead to defective parts at first sight, these might be discovered once high voltage is up again.

Therefore the following test procedure was created to switch exposures just for 1ms before any part of the generator might be overloaded from a defective tube or HV cable.

- Switch the generator OFF.
- Establish the **test cable with diode** at the backpanel service measuring points:

  EZX74 (CTRL_X_C/ = cathode of diode) > open plug

  and

  EZX77 (X_ACT_S/ = anode of diode) > green plug cover

- Establish **just one side** first (with the 4mm plug) of the **test cable with resistor** at the mAs short-circuit plug (either side, short-circuit plug remains in) of the measuring circuit EG100 (if access is not possible loosen screening cap of primary lines.)
- Establish oscilloscope connections:

  channel 1 = anode EZ130 X4 AV_AN 20kV = 1V 0.5V/div

  channel 2 = cathode (also positive) EZ130 X5 AV_CA 20kV = 1V 0.5V/div

  ground = EZ130 X6/X32 GNDA

  trigger = signal CTRL_X_C/ at EZX74 **must** be used , negative slope, trigger level 2.5V

  (if a third probe is not available use one channel for triggering with CTRL_X_C/ and check anode and cathode side individually)

  time base = 200µs/div, trigger delay -1div

Explanation:

With these hardware modifications and exposure settings the exposure time is only 1ms.
The additional resistor simulates an emission current of 500mA which lets the mAs counter of mA-control terminate the exposure at 1ms (= 0.5mAs).

Under normal conditions the mAs counter is triggered by the signal X_ACT_S/. As this might be missing due to a problem in the system the additional diode drives, the kV start command CTRL_X_C/ also at X_ACT_S/ to trigger the mAs counter and ensures the short exposure. The oscilloscope must be triggered with CRTL_X_C/ for the same reason to get a display.

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- Switch ON the generator.
- Set one RGDV for the following procedure or create a new RGDV just for the test (ignore other settings in Data Set A):

Enable handswitch at generator desk:	Yes
Syncmaster present (e.g. grid contact):	No
Exposure switch type:	Double Step
Mounted radiographical controller:	none
Release circuit adaptation unit:	none
Mounted tomo extension:	none

- Start with **40kV**, **50mA**, **10ms** (= 0.5mAs). If the tube is not adapted set **40kV 0.5mAs**.
- Establish the **second side** of the **test cable with resistor** at backpanel plug

  EZX18 (Optimus 50)

  or

  EZX19 (OM 65/80) (backpanel layout page Z2-5.2).

  If EZX19 is used take 1WA X42 or 2WA X42 or 1WB X42 (see layout Z2-15.1).

NOTE!

If the test cable with resistor is connected, mA-control EZ119 might display a FATAL error condition (LED on) after a certain time. Then remove the plug and warmstart the generator.
Do not put the plug back in before the generator is in ready condition. Then continue.

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- Switch one exposure.
- Compare the measured result with the four possible cases of the table.

  Case 1:

  Both, anode and cathode side, have the same kV rising slope and value up to the point when the exposure terminates (which is almost the set kV).

  If so, increase kV value in 10kV steps up to the programmed max kV tube limit or the max. value which is used for application and check results with the table cases 1, 2 and 3 accordingly (settings 50mA + 10ms or 0.5mAs for a non-adapted tube **must remain!**).

  If the result is not case 1 carry out case dependent ***actions*** given in the table below and switch a second exposure.

CAUTION!
Case 4 must not be carried out with a value higher than 40kV.

	exposures to be switched with 50mA 10ms or 0.5mAs	measuring results		*actions* + ►analysis	
		anode EZ130 X4	cathode EZ130 X5	HV cable	tube
case 1	one exposure	50% of set kV	50% of set kV	► **OK**	► **OK**
				increase kV by 10kV	
case 2	1st exposure	0 ≠ **anode kV** < **cathode kV** ≠ 0 or 0 ≠ **anode kV** > **cathode kV** ≠ 0		*interchange anode and cathode HV cables (at both sides, tube and transformer)*	
	2nd exposure			no change of measured levels: ► tube defective measured levels change: ► HV cable(s) defective	
case 3	1st exposure	**set** kV or **0**kV	**0**kV or **set** kV	*interchange anode and cathode HV cables (at both sides, tube and transformer)*	
	2nd exposure	**0**kV or **set** kV	**set** kV or **0**kV	► HV cable at the **0**kV side defective	
case 4	1st exp. **40**kV	**0**kV	**0**kV	*remove anode HV cable from tube **and** HV transformer side*	
	!! this test with 40kV only, no higher kV !!				
	2nd exp. **40**kV	**40**kV or **20**kV	**0**kV or **20**kV	► tube defective	

- Compare measuring results with examples of oscilloscope charts on next page.
- **Remove test cables with resistor and diode!**

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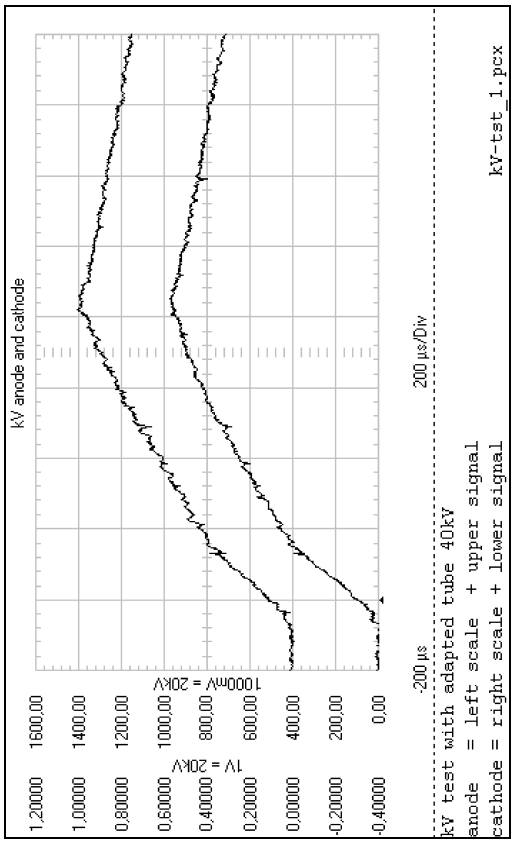
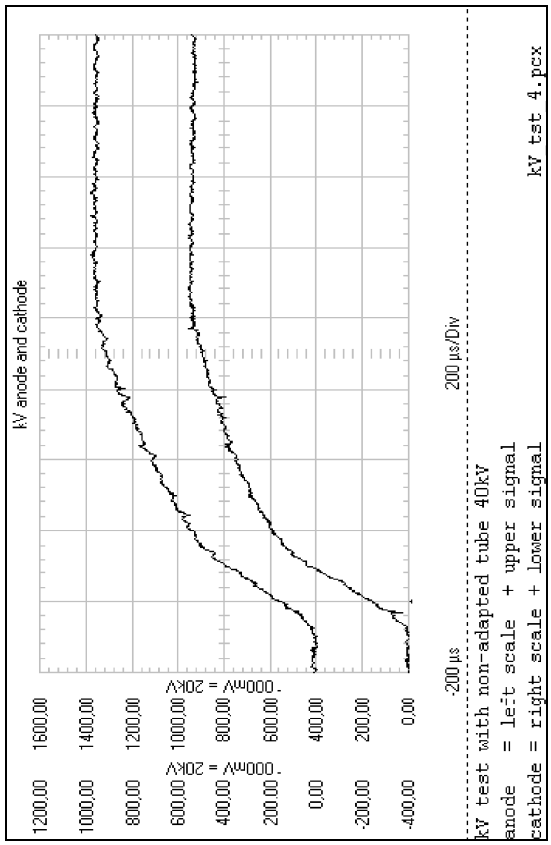
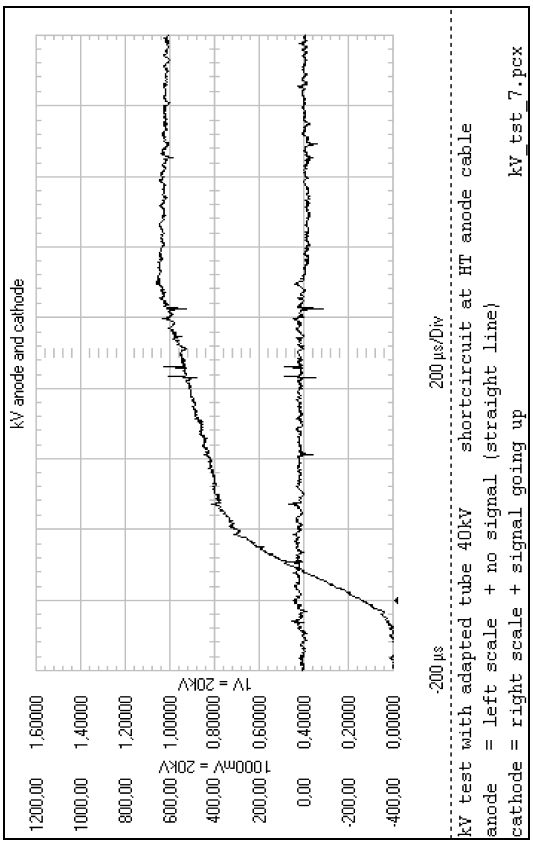


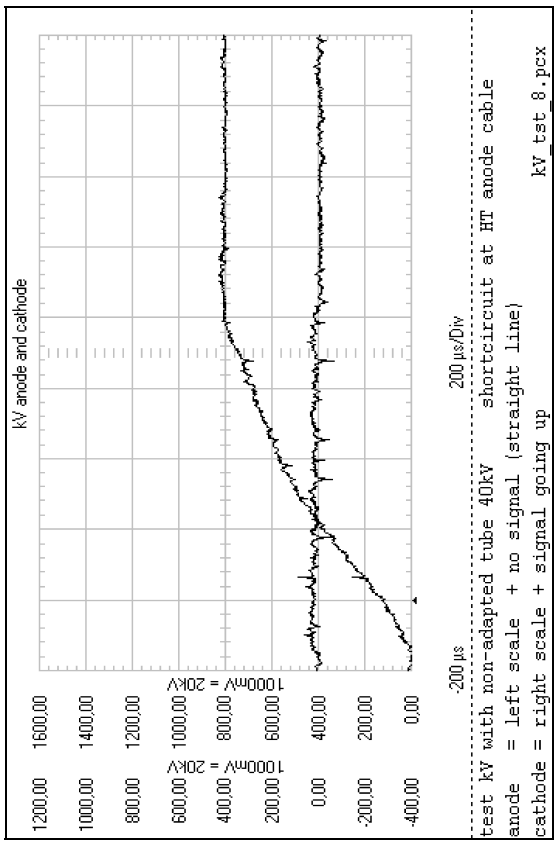
▲adapted tube, tube and cable OK▲



▲non-adapted tube, tube and cable OK▲



▲adapted tube, anode cable short-circuit▲



▲non-adapted tube, anode cable short-circuit▲

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12. Measuring of primary currents

- Switch OFF the generator and wait 1 minute for the converter DC to be discharged.
- Measure with the oscilloscope:

Signals:

Optimus **50**:
Establish one oscilloscope probe (signal and screen) at the current transformer secondary side.
Establish the second probe at EZ130 X3 AV_HT (actual value high voltage) and ground EZ130 X6.

Optimus **65/80**:
Establish both oscilloscope probes at the current transformers secondary side.
Check that signal and ground are at the same 1 + 2 transformer connections (polarity).

Trigger:

Use external trigger negative slope with low active CTRL_X_C/ signal at EX74 (backpanel).
If a third probe for an external trigger is not available:

Optimus **50**:
Use channel 2 (kV actual value AV_HT = 20kV/Volt) positive slope, trigger value according to probe divider.

Optimus **65/80**:
Set the trigger point level at channel 1 or 2 according to the expected amplitudes (see charts).

Time base:

According to charts. A trigger delay time (settings see charts) can be useful to see the start of the signals.

> **NOTE!**
> *Digital oscilloscopes sometimes display waveforms and spikes which do not exist or only parts of the signal are displayed.*

The following charts were made with a 100MHz oscilloscope with different magnification factors (= time base).

- Switch the generator back ON.
- Set **40kV**, **50mA**, **10ms** (any focus). In case the tube is not adapted set **40kV**, **0.5mAs**.
- Compare waveforms with the charts on the following 4 pages.

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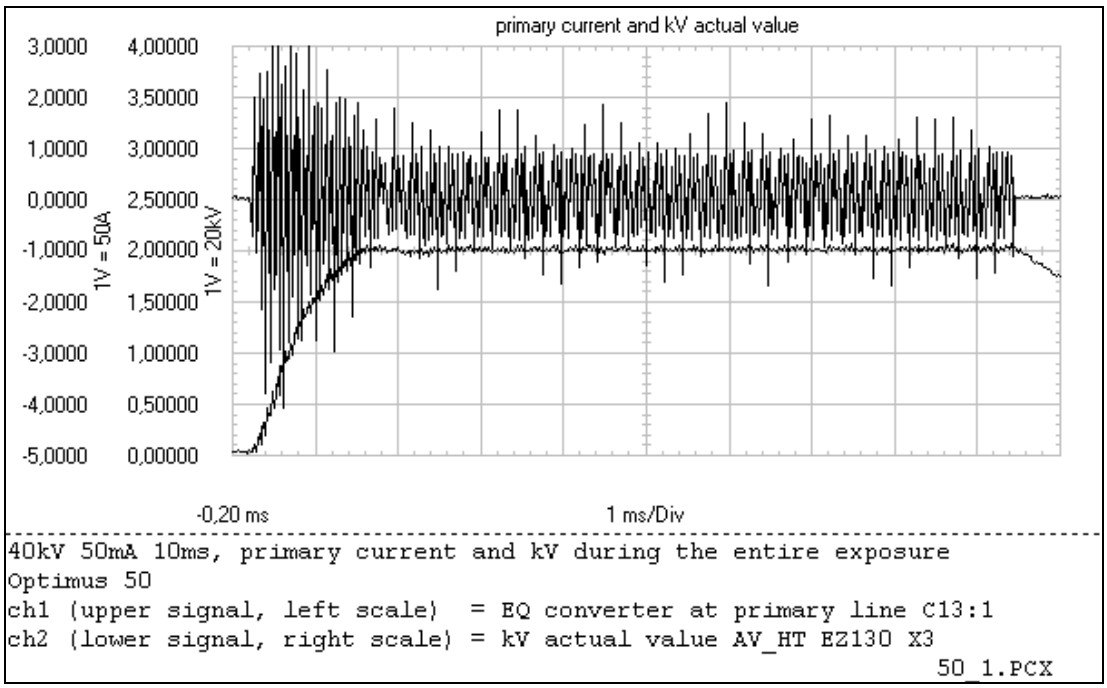
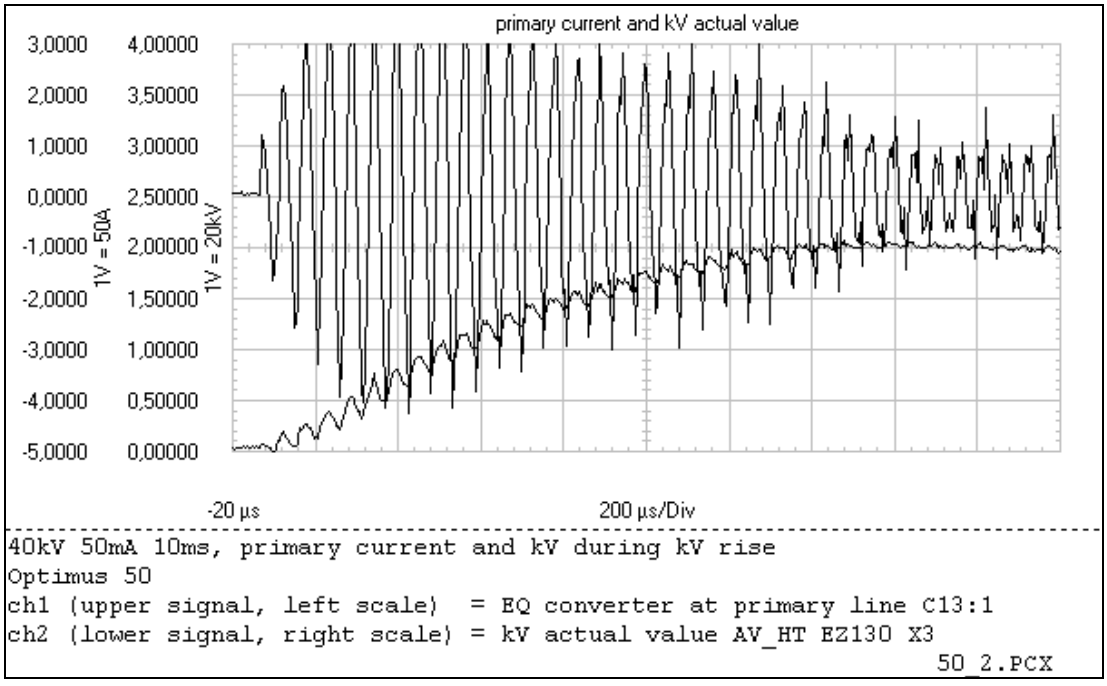
Optimus 50 tube adapted:





The primary current values must be within the range of the lower chart ±10%.

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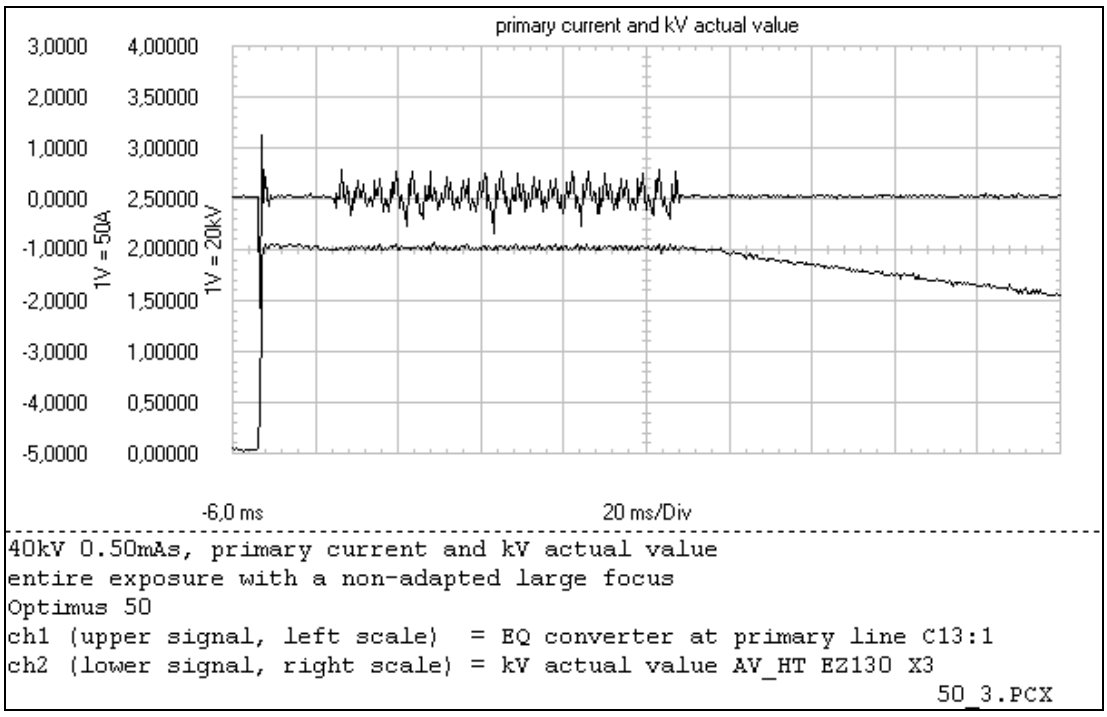
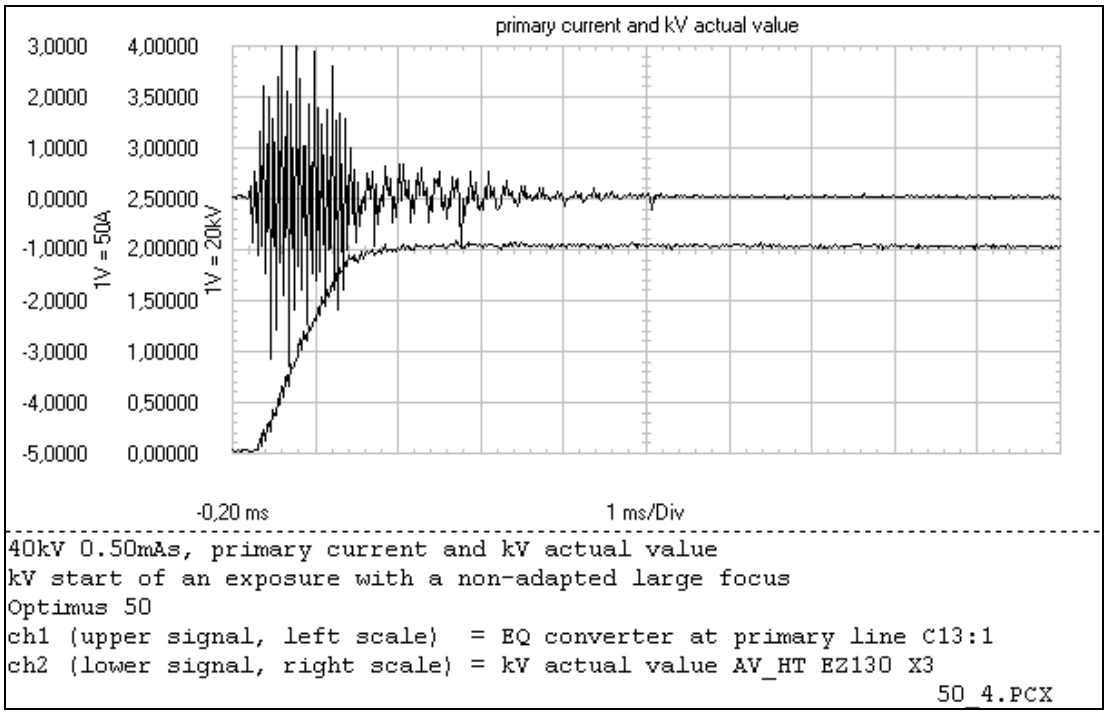
Optimus 50 tube not adapted:





The primary current values must be within the range of the lower chart of page 26 ±10%.

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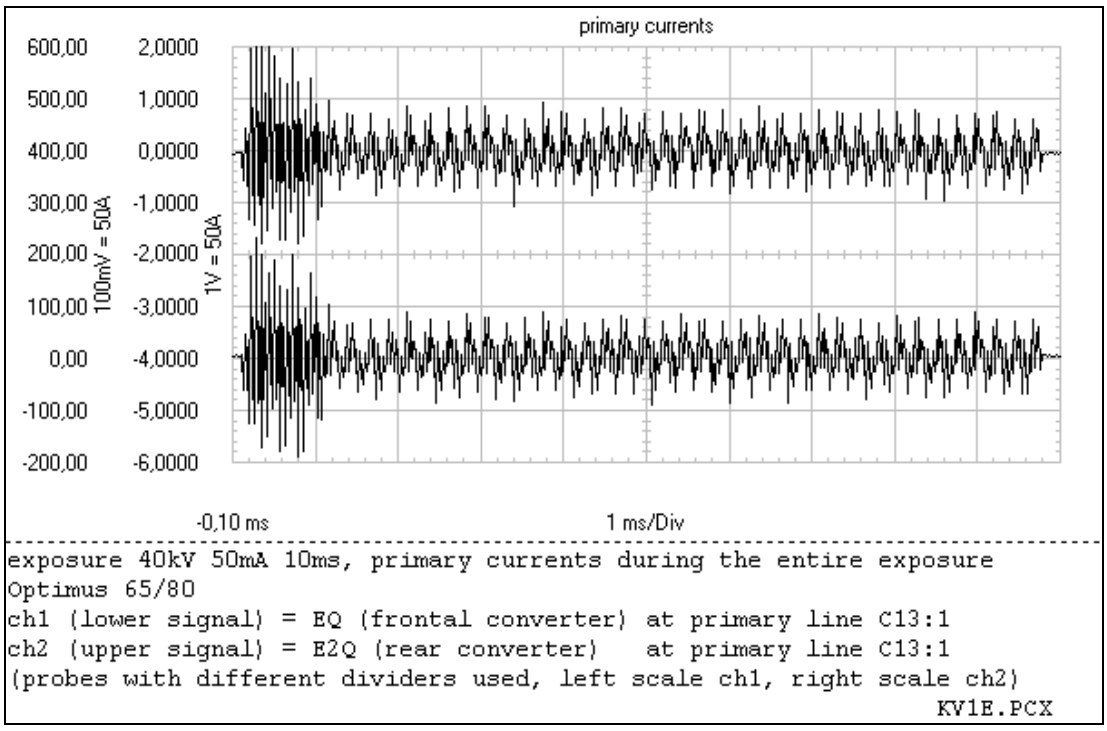
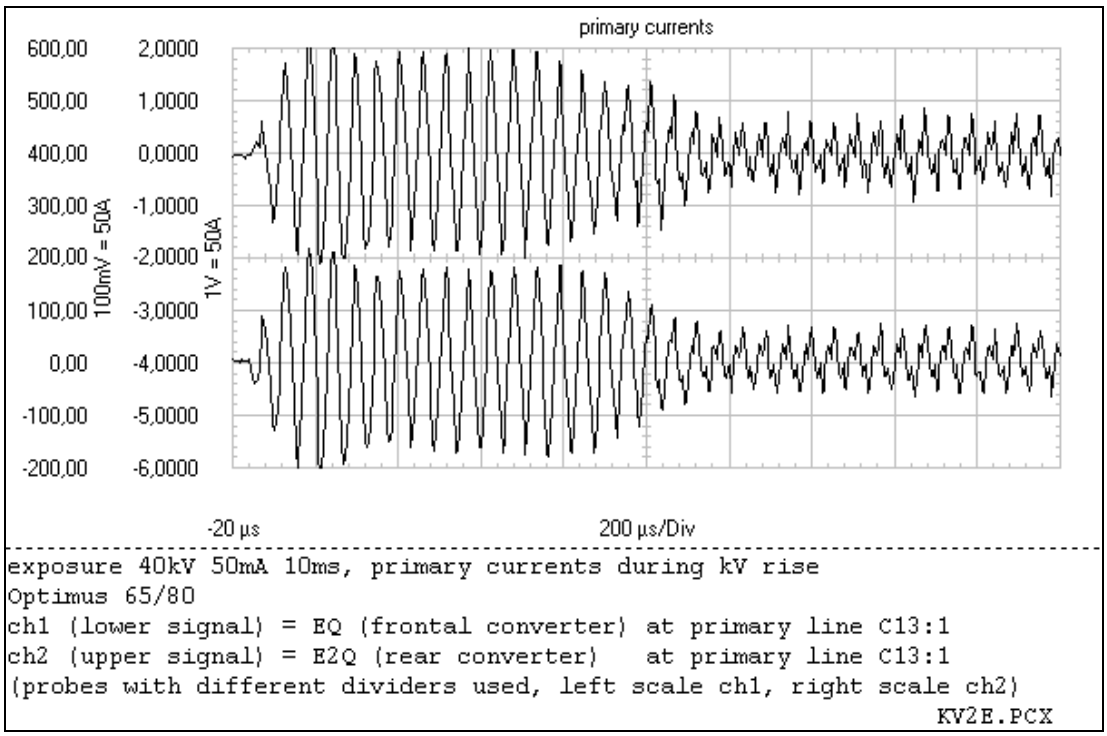
Optimus 65/80 tube adapted:



exposure 40kV 50mA 10ms, primary currents during the entire exposure
Optimus 65/80
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter) at primary line C13:1
(probes with different dividers used, left scale ch1, right scale ch2)
KV1E.PCX



exposure 40kV 50mA 10ms, primary currents during kV rise
Optimus 65/80
ch1 (lower signal) = EQ (frontal converter) at primary line C13:1
ch2 (upper signal) = E2Q (rear converter) at primary line C13:1
(probes with different dividers used, left scale ch1, right scale ch2)
KV2E.PCX

If waveforms are not symmetrical replace HV transformer.

The primary current values must be within the range of the lower chart ±10%.

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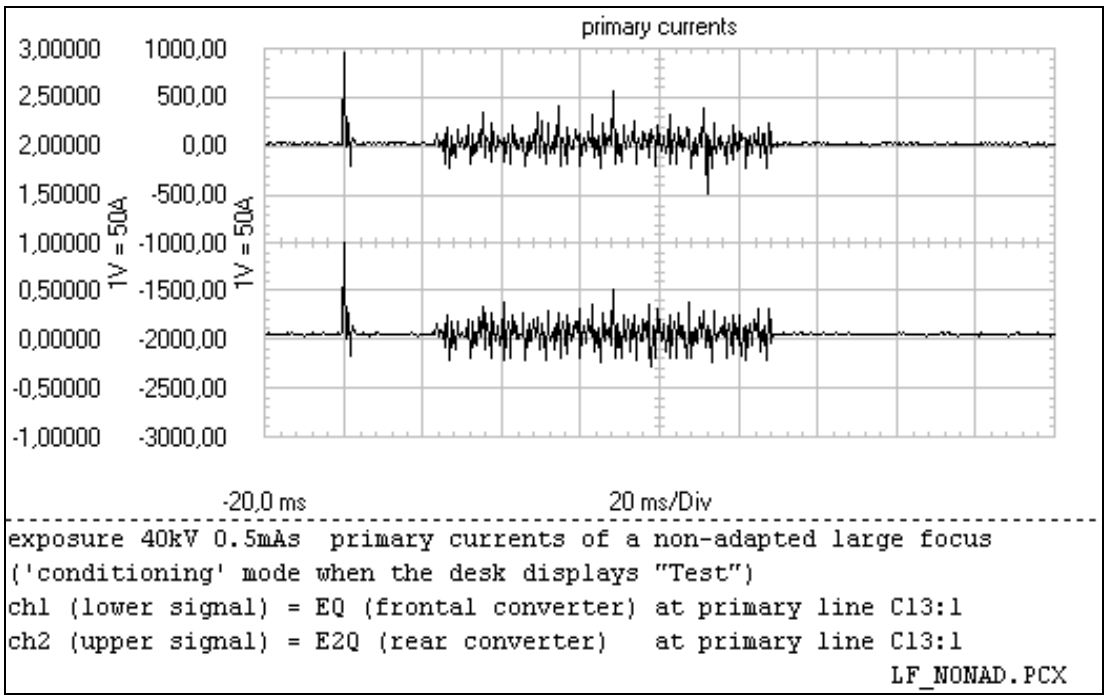
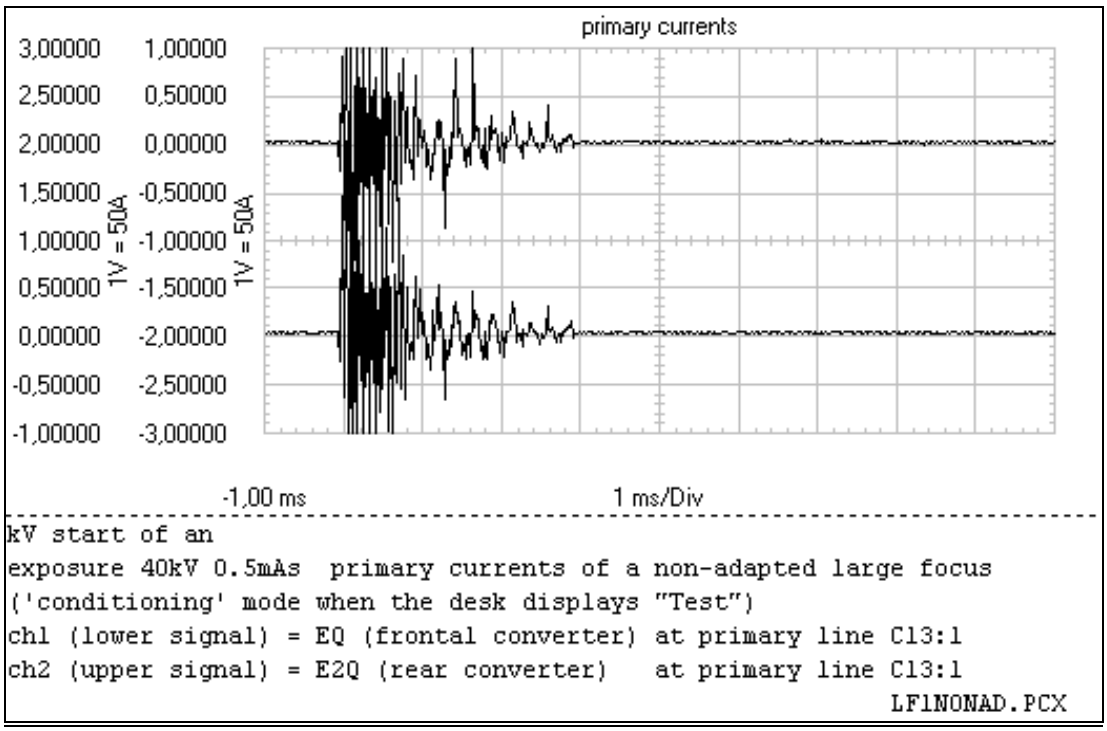
Optimus 65/80 tube not adapted:





If waveforms are not symmetrical replace HV transformer.

The primary current values must be within the range of the lower chart of page 28 ±10%.

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12.1. Measuring of the resonance frequency

The resonance frequency of

- the parallel primary coils (anode and cathode) at a 50kW generator driven by 1 converter only
or
- the individual primary coils (anode or cathode) at a 65/80kW driven by 1 converter each

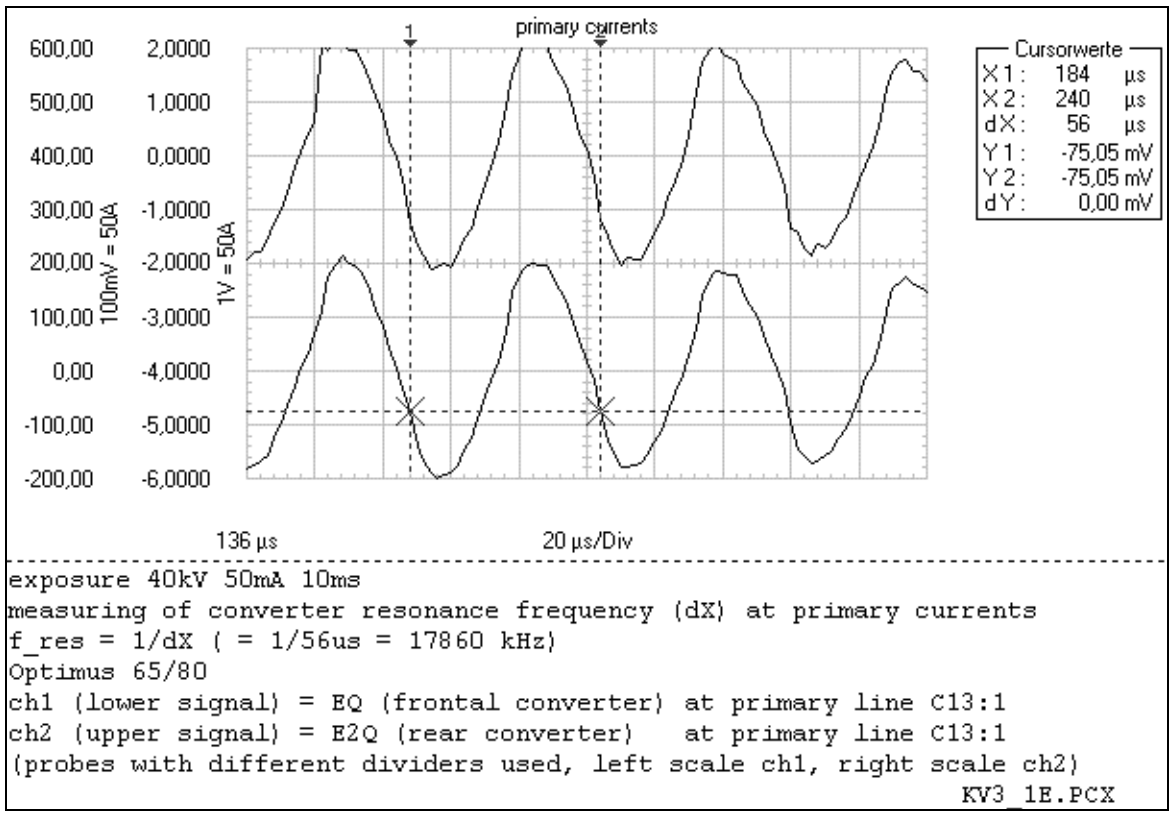
must always be the same.

With a tolerance of 5% for the primary coil inductance and for the resonance capacitors in the converters the resonance frequency must be within a range of
17.160kHz (1/f = 58.3µs) and 18.970kHz (1/f = 52.7µs).

Optimus **65/80** with **2** converters:
Both currents must be in phase (if not check probes at current transformer pins 1 + 2).

- Compare with chart.

It does not matter if the tube is adapted or not.



Optimus **50**:
If the resonance frequency is not within the specified range the suspected part might be
- the HV transformer
- the resonance capacitor(s) of the converter.

Optimus **65/80**:
Both resonance frequencies must be within the specified range. If not the suspected part might be
- the HV transformer
- the resonance capacitor(s) of the individual converter.

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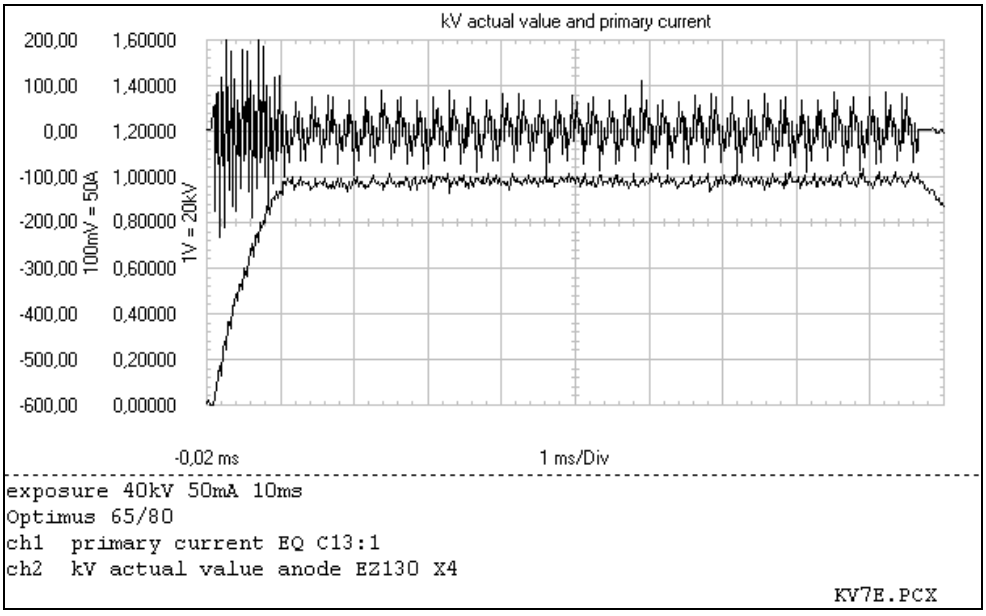
12.2. Measurement of kV behavior with an adapted tube

- Switch OFF the generator and wait until the converter DC is discharged.
- Establish one oscilloscope probe at
  EZ130 X4 AV_AN actual value high voltage **anode**
  and
  ground EZ130 X6.
  Settings see chart.
  The second probe remains at the primary current anode side (frontal converter 65/80kW or the frontal converter of Optimus 50).
- Switch an exposure and compare with chart.
- Establish one oscilloscope probe at
  EZ130 X5 AV_CA actual value high voltage **cathode** (also positive)
  and
  ground EZ130 X6.
- Establish the second probe at the primary current cathode side (rear converter 65/80kW).
- Switch an exposure **40kV**, **50mA**, **10ms** and compare with chart.

Tube adapted:



If kV values are not symmetrical replace HV transformer. Asymmetry error messages like 02HW (warning in the background) or 02HX (error) might also come up (measured values see detail screens error log).

Tube arcing messages like 02WG (warning in the background) or 02WH (error) might appear. These should be visible at the oscilloscope trace as break-in of kV within a time of < 10µs.
It might be a problem of the tube, either because of its age or because it has not properly been conditioned.

In case of errors 02HG (warning in the background) and 02HH (error) realign the duty cycle factor according to ADJUSTMENTS chapter 2 revision provided with the kit.
File the document in the SUBSYSTEM manual OPTIMUS.

If a filament is not adapted adapt it before realigning the duty cycle; otherwise the adjustment is not possible.

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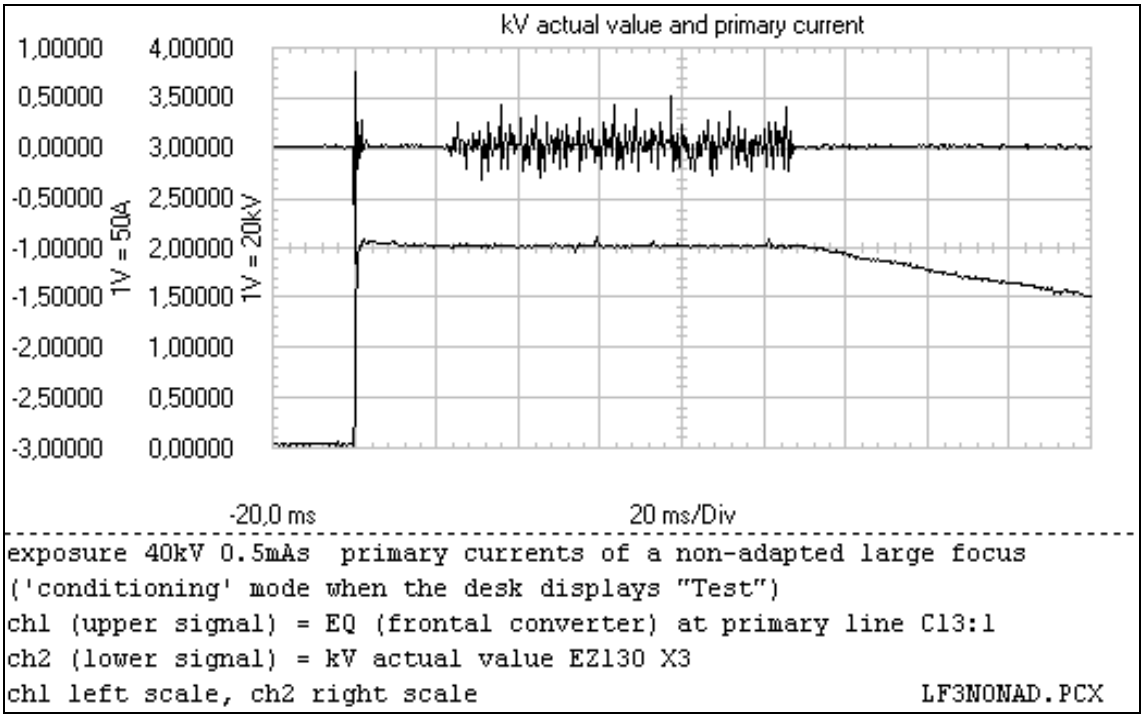
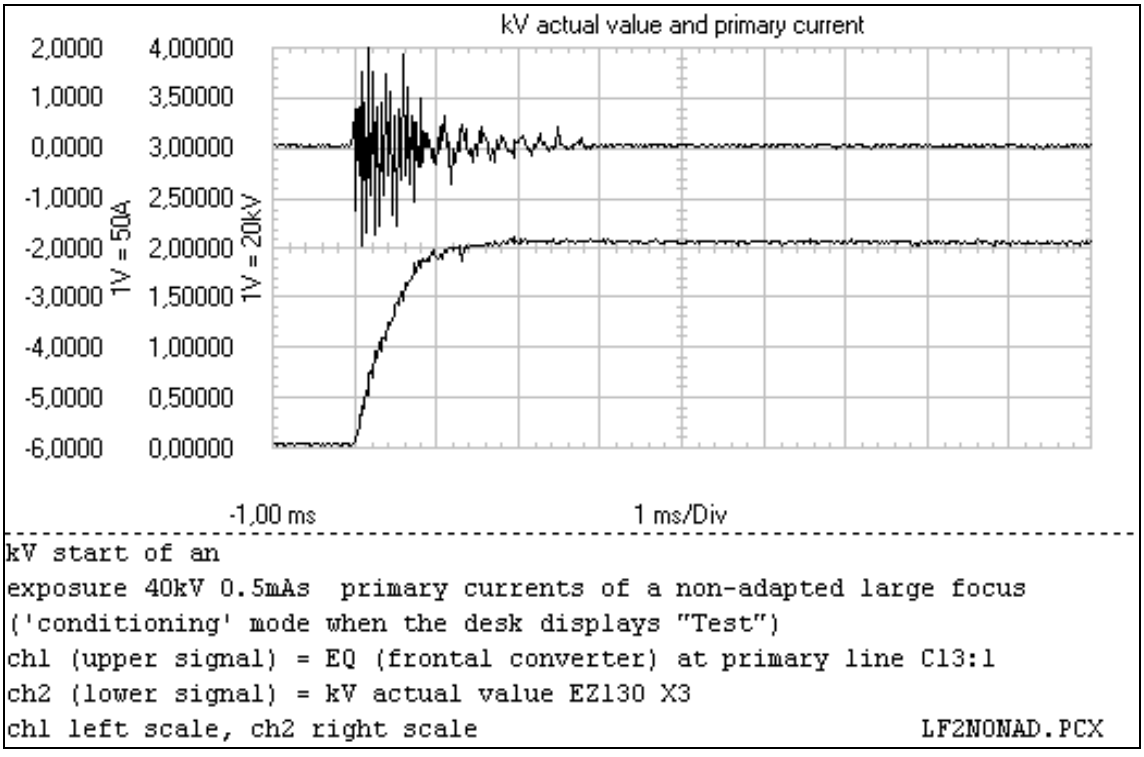
12.3. Measuring of kV behavior with a non-adapted tube (Optimus 65/80)

The primary current behavior is different to an adapted condition as the exposure starts with 2A filament current which is brought up to filament current limit of the selected focus once high voltage is at its nominal value. Measurements have been made at kV actual value AV_HT EZ130 X3. To check the kV symmetry use the settings of chapter 12.2.





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13. Reconditioning of the tube(s)

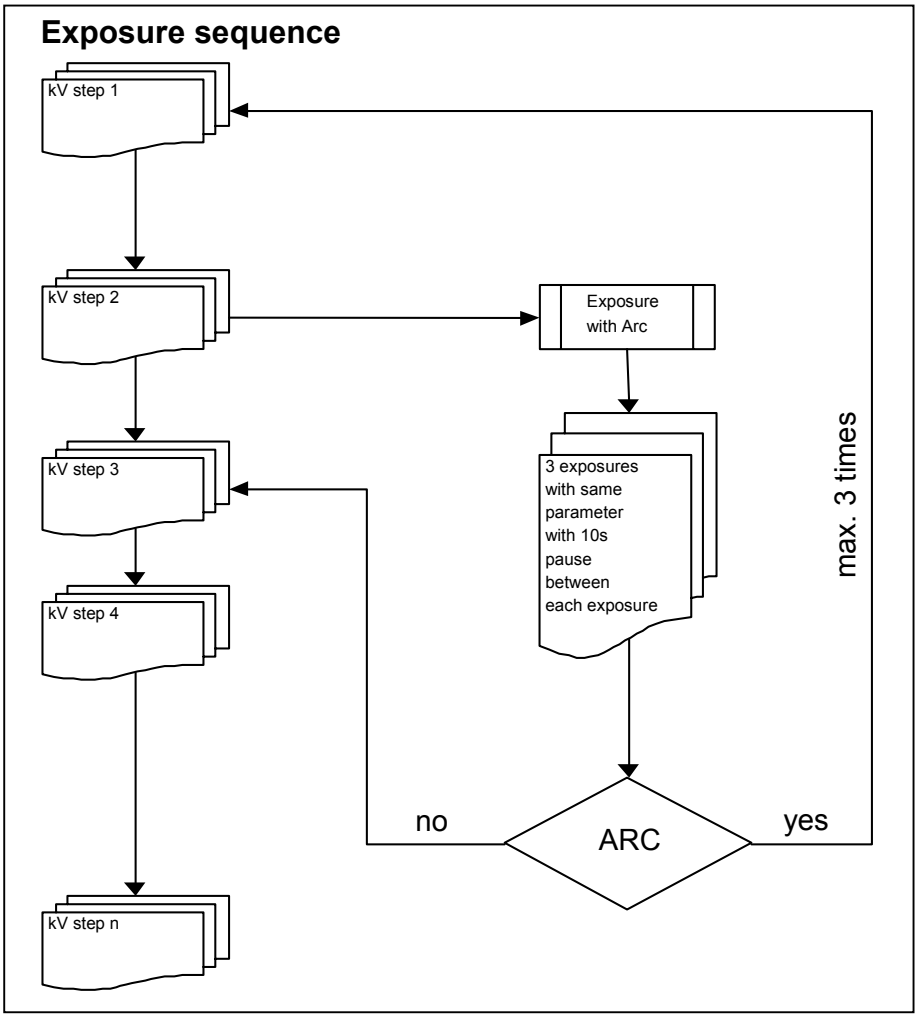
- Establish one oscilloscope probe at
  EZ130 X3 AV_HT actual value high voltage (total kV, 20kV/V) and ground EZ130 X6.

Use large focus only!

- Run reconditioning procedure (see next page) for the applicable kV range only.
  If, for instance, 125kV is the max. kV value during normal application, perform reconditioning just up to the next kV step = 130kV.

If the tube arcs at a certain kV value proceed as follows:

- Switch another 3 exposures with same parameters and 10s pause between subsequent exposures.
- If the last exposure of a sequence does not arc proceed with next kV step.
- If the last exposure still arcs go one kV step back and start again with the normal procedure.
  If this routine has been performed three times without improvement: **==> replace the tube!**



NOTE!
If a tube arcs at a kV value which is not required for application the max kV (e.g.125kV) value can be reduced with
XRGSCOPE >> PROGRAM >> TUBES >> TUBE LIMITS >> MAX. TUBE VOLTAGE LIMIT [KV]: [125]

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Tube adapted				Tube not adapted	
Switch the number of exposures given for every data set of the table.					
kV	**mA**	**ms**	exposures	**kV**	**mAs**
80	10	50	< 1 >	80	0.5
80	10	500	< 1 >	80	5
80	200	250	< 1 >	80	50
10 seconds pause				10 seconds pause	
80	max mA	100	< 1 >	80	100
1 minute pause				1 minute pause	
90	10	50	< 1 >	90	0.5
90	10	500	< 1 >	90	5
90	200	250	< 1 >	90	50
10 seconds pause				10 seconds pause	
90	max mA	100	< 1 >	90	100
1 minute pause				1 minute pause	
100	10	50	< 1 >	100	0.5
100	10	500	< 1 >	100	5
100	200	250	< 1 >	100	50
10 seconds pause				10 seconds pause	
100	max mA	100	< 1 >	100	100
1 minute pause				1 minute pause	
110	10	50	< 1 >	110	0.5
110	10	500	< 1 >	110	5
110	200	250	< 1 >	110	50
10 seconds pause				10 seconds pause	
110	max mA	100	< 1 >	110	100
1 minute pause				1 minute pause	
120	10	50	< 1 >	120	0.5
120	10	500	< 1 >	120	5
120	200	250	< 1 >	120	50
10 seconds pause				10 seconds pause	
120	max mA	100	< 1 >	120	100
1 minute pause				1 minute pause	
130	10	50	< 1 >	130	0.5
130	10	500	< 1 >	130	5
130	200	250	< 1 >	130	50
10 seconds pause				10 seconds pause	
130	max mA	100	< 1 >	130	100
1 minute pause				1 minute pause	
140	10	50	< 1 >	140	0.5
140	10	500	< 1 >	140	5
140	200	250	< 1 >	140	50
10 seconds pause				10 seconds pause	
140	max mA	100	< 1 >	140	100
1 minute pause				1 minute pause	
145	10	50	< 1 >	145	0.5
145	10	500	< 1 >	145	5
145	200	250	< 1 >	145	50
10 seconds pause				10 seconds pause	
145	max mA	100	< 1 >	145	100
1 minute pause				1 minute pause	
148	10	50	< 1 >	148	0.5
148	10	500	< 1 >	148	5
148	200	250	< 1 >	148	50
10 seconds pause				10 seconds pause	
148	max mA	100	< 1 >	148	100
1 minute pause				1 minute pause	
150	10	50	< 1 >	150	0.5
150	10	500	< 1 >	150	5
150	200	250	< 1 >	150	50
10 seconds pause				10 seconds pause	
150	max mA	100	< 1 >	150	100

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14. Final system test

- If the generator works error-free at this stage switch it OFF and cut it from mains.

WARNING!

Wait at least 1 minute until the converter DC is discharged.

- Remove current transformer(s) from the primary lines and reestablish the primary lines at the resonance capacitors.
- Close the converter covers.
- Put mains and the generator back ON.
- Run a final system test with exposures and fluoroscopy where present.

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List of checked parts of generator S/N: _____

Please add this list to returned parts.

ENK2	phase 1	1 - 2	❒ open	❒ welded
	phase 2	3 - 4	❒ open	❒ welded
	phase 3	5 - 6	❒ open	❒ welded
EN	**: R1**		❒ open	
	: R2		❒ open	
	: R3		❒ open	
ENF1	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENF2	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENK1	phase 1	2 – 1	❒ open	❒ welded
	phase 2	4 – 3	❒ open	❒ welded
	phase 3	6 – 5	❒ open	❒ welded

Rectifier EQV5	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 1	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 2	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 3	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 4	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V501	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V502	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V503	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V504	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R506/507/508	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R509/510/511	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Cable harness	EQ	❒ 2 = OK	❒ 1 = defective	E2Q ❒ 2 = OK	❒ 1 = defective

>> Converter **EQ** ❒ OK ❒ defective unit barcode# frontal: _____
E2Q ❒ OK ❒ defective unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Res. capacitor C13	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective

H.V. cable ❒ OK ❒ defective

X-Ray tube 1 ❒ OK ❒ defective tube type: _____ tube S/N: _____
X-Ray tube 2 ❒ OK ❒ defective tube type: _____ tube S/N: _____

H.V. transformer ❒ OK ❒ defective tank S/N: _____

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List of checked parts of generator S/N: _____

Please add this list to returned parts.

ENK2	phase 1	1 - 2	❒ open	❒ welded
	phase 2	3 - 4	❒ open	❒ welded
	phase 3	5 - 6	❒ open	❒ welded
EN	**: R1**		❒ open	
	: R2		❒ open	
	: R3		❒ open	
ENF1	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENF2	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENK1	phase 1	2 – 1	❒ open	❒ welded
	phase 2	4 – 3	❒ open	❒ welded
	phase 3	6 – 5	❒ open	❒ welded

Rectifier	**EQV5**	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 1		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 2		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 3		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 4		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V501		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V502		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V503		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V504		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R506/507/508		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R509/510/511		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective

Cable harness EQ ❒ 2 = OK ❒ 1 = defective E2Q ❒ 2 = OK ❒ 1 = defective

>> Converter **EQ** ❒ OK ❒ defective unit barcode# frontal: _____
E2Q ❒ OK ❒ defective unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective
Res. capacitor C13	EQ	❒ OK	❒ defective	E2Q	❒ OK	❒ defective

H.V. cable ❒ OK ❒ defective

X-Ray tube 1 ❒ OK ❒ defective tube type: _____ tube S/N: _____
X-Ray tube 2 ❒ OK ❒ defective tube type: _____ tube S/N: _____

H.V. transformer ❒ OK ❒ defective tank S/N: _____

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List of checked parts of generator S/N: _____

Please add this list to returned parts.

ENK2	phase 1	1 - 2	❒ open	❒ welded
	phase 2	3 - 4	❒ open	❒ welded
	phase 3	5 - 6	❒ open	❒ welded
EN	**: R1**		❒ open	
	: R2		❒ open	
	: R3		❒ open	
ENF1	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENF2	L1 – T1		❒ open	❒ welded
	L2 – T2		❒ open	❒ welded
	L3 – T3		❒ open	❒ welded
ENK1	phase 1	2 – 1	❒ open	❒ welded
	phase 2	4 – 3	❒ open	❒ welded
	phase 3	6 – 5	❒ open	❒ welded

Rectifier	**EQV5**	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 1		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 2		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 3		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
IGBT 4		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V501		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V502		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V503		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Diode V504		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R506/507/508		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Resistors R509/510/511		EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective

Cable harness EQ ❒ 2 = OK ❒ 1 = defective E2Q ❒ 2 = OK ❒ 1 = defective

>> Converter **EQ** ❒ OK ❒ defective unit barcode# frontal: _____
E2Q ❒ OK ❒ defective unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective
Res. capacitor C13	EQ	❒ OK	❒ defective	E2Q ❒ OK	❒ defective

H.V. cable ❒ OK ❒ defective

X-Ray tube 1 ❒ OK ❒ defective tube type: _____ tube S/N: _____
X-Ray tube 2 ❒ OK ❒ defective tube type: _____ tube S/N: _____

H.V. transformer ❒ OK ❒ defective tank S/N: _____

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